

ESCI 107 – The Atmosphere
Lesson 11 – Global Circulation

Reading: *Meteorology Today*, Chapter 10

THE GLOBAL CIRCULATION

- ***Latitudinal heat imbalance*** – The tropics receive more radiation than they emit. The polar regions emit more radiation than they receive. This causes an imbalance in heat.
- If there were no heat transferred between the tropics and the polar regions, the tropics would get hotter and hotter, while the poles would get colder and colder.
- ***THE LATITUDINAL HEAT IMBALANCE IS WHAT DRIVES THE CIRCULATION OF THE ATMOSPHERE AND OCEANS.***
- ***THE CIRCULATION OF THE ATMOSPHERE AND OCEANS BOTH ACT TO TRANSFER HEAT FROM THE TROPICS TO THE POLES.***
- One way to accomplish the transfer of heat from the equator to the poles would be to have a single circulation cell that was upward in the tropics, poleward aloft, downward at the poles, and equatorward at the surface. This is the single-cell circulation model first proposed by Hadley in the 1700's.
- Because the earth rotates, instead of a single-cell circulation there is a three-cell circulation.
 - Because the Coriolis force act to the right of the flow (in the Northern Hemisphere), the flow around the 3-cells is deflected. This gives rise to the three main wind belts in each hemisphere at the surface:
 - The easterly *trade winds* in the tropics
 - The *prevailing westerlies*
 - The *polar easterlies*
 - The *doldrums* are the region near the equator where the trade winds from each hemisphere meet. This is also where you find the *intertropical convergence zone (ITCZ)*. It is characterized by hot, humid weather with light winds.
 - The *horse latitudes* are the region between the trade winds and the prevailing westerlies. In this region the winds are often light or calm, and were so-

- named because ships would often have to throw their horses overboard due to lack of feed and water.
- The *polar front* lies between the polar easterlies and the prevailing westerlies.

OBSERVED GLOBAL DISTRIBUTION OF PRESSURE AND WIND

- The three-cell circulation model would have associated with it the following pressure belts.
 - *Equatorial low* – A belt of low pressure associated with the rising air in the ITCZ.
 - *Subtropical high* – A belt of high pressure associated with the sinking air of the horse latitudes.
 - *Subpolar low* – A belt of low pressure associated with the polar front.
 - *Polar high* – A high pressure associated with the cold, dense air of the polar regions.
- The three-cell circulation model is an idealization. In reality, the winds are not steady, and the pressure belts are not continuous. There are three main reasons for this
 - The surface of the earth is not uniform, or smooth. There is uneven heating due to land/water contrasts.
 - The wind flow itself can become unstable and generate “eddies.”
 - The sun doesn’t remain over the equator, but moves from 23.5N to 23.5S and back over the course of a year.
- Instead, there are *semi-permanent high- and low-pressure systems*. They are semi-permanent because they vary in strength or position throughout the year.
 - Wintertime
 - Polar highs over Siberia and Canada
 - Pacific High and Azores High (parts of the subtropical high pressure system)
 - Aleutian Low and Icelandic Low
 - Summertime

- The Azores high migrates westward and intensifies to become the Bermuda High
- Pacific high also moves westward and intensifies
- Polar highs are replaced by low pressure
- Heat low forms over southern Asia

MONSOONS

- A *monsoon* is defined as a wind system that has a pronounced seasonal reversal.
- The most famous monsoon is the *Asian monsoon*.
 - In the summer a heat low forms over southern Asia. The flow into the heat low brings in moist, tropical southwesterly flow over India and Southeast Asia.
 - The rainiest regions are in the Himalayas, where orographic lifting creates massive rainfall (82.5 feet of rain in a year!).
 - In the winter, a strong high-pressure system dominates over Asia, bringing dry, northeasterly flow off of the continent over Southeast Asia and India.
- The *North American Monsoon*
 - A weaker monsoon occurs over the deserts of Arizona and Northern Mexico in summer. A heat low forms, and brings in moist air from the Gulf of California and the Gulf of Mexico.

THE MID-LATITUDE WESTERLIES AND THE JET STREAMS

- In the idealized 3-cell model of circulation the middle cell had flow toward the equator aloft, which would give easterly winds. **THIS IS NOT THE CASE!**
- Instead, there are westerly winds aloft. This is due primarily to the temperature contrast between the poles and the tropics.
- The strongest westerly winds are found over the polar front. These are known as the *midlatitude, or polar, jet stream*.
 - A jet stream is a ribbon of fast moving air, almost like a river of air.
 - Jet streams are found just below the tropopause.
 - The polar jet is not continuous. It can sometimes split.

- The polar jet is located in the vicinity of the polar front, and meanders with the polar front. It is farther south in the winter, and moves to the north in the summer.
- The polar jet is stronger in the winter than in the summer, due to the greater temperature contrast across the polar front.
- Since migratory low-pressure systems move along the polar front, the polar jet stream is sometimes thought to steer the lows. This is why the T.V. weatherman refers to the polar jet as the *storm track*.
- There is another jet stream that is only found in the winter. It is the *subtropical jet stream*.
 - The subtropical jet is found to the south of the polar jet.
 - The subtropical jet is not associated with a surface front.

EL NINO AND LA NINA

- The west coast of South America usually experiences a cold current called the Peruvian current. There is also upwelling of cold, deep water during their summer.
- This cold, upwelling is important for fisheries, since the cold water is nutrient rich.
- In December, there is usually a short period of warming caused by a warm, countercurrent. This event occurs near Christmas, so the natives call it *El Nino* in honor of the Christ child.
- At intervals of 3 to 10 years the warm current stays and becomes unusually strong. It is these strong events that we now refer to as *El Nino*.
- Usually the warm water is driven to the Western Pacific by the trade winds. El Nino occurs when the trade winds become very light, or even reverse, allowing the warm surface water to flow eastward. This also shuts off the upwelling of cold water that would normally occur.
- These warmer waters in the East Pacific not only devastate the fisheries, but impact weather patterns around the globe, far from the tropical oceans.

- **La Nina is the name for the opposite of El Nino, when the surface waters off the west coast of South America become abnormally cold. It also effects weather patterns far from the tropics.**